Synopsis of the Research Proposal

for

DOCTOR OF PHILOSOPHY

in

Civil Engineering

Application of Hydrological Models for Runoff Prediction in Ungauged Basins

(Faculty of Engineering and Technology)

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SYNOPSIS

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INDRODUCTION

Water is the most important natural resource on the earth. Without water life cannot be imagined. About 71% of the Earth's surface is covered by water out of which about 97% of total water is available in ocean in the form of salt water that cannot be use directly, about 2.26% of water is available in the form of glaciers and polar ice caps, even though it is a fresh water, it cannot be directly consumed. There is about 0.75% of groundwater and 0.01% of surface resource of fresh water. The problem of water is that it is not always present in the proper place, at the proper time, and in proper quantity. Water on the earth is not stagnant. It continuously moves from one place to another or from one form to another. This continuous movement of water is represented by the hydrologic cycle. The hydrological cycle is the phenomenon in which various processes like evaporation, precipitation, interception, transpiration, surface runoff, infiltration and percolation are involved.

People tap the water cycle for their own uses. After their uses, water is allowed to flow on the ground or soaked into the ground. Number of problems related to quantity and quality of water created while transport this water through the hydrological cycle. Hydrology is the science, which helps for solving the problems related to water. Hydrologists play a vital role in finding the solutions of the water related problems.

Drainage basins are a fundamental landscape unit for the cycling of water, sediment and dissolved geochemical and biogeochemical constituents. As such, they integrate all the aspects of the hydrological cycle within a defined area that can be studied, quantified and acted upon. The drainage basin, thus, is a metaphor for integration of hydrological processes related to surface water, ground water, evapotranspiration etc. and the explicit coupling hydrology, geo chemistry and ecology (Sivapalan et al., 2003).

An ungauged basin is one with inadequate records (in terms of both data quantity and quality) of hydrological observations to enable computation of hydrological variables of interest (both water quantity and quality) at the appropriate spatial and temporal scales, and to the accuracy acceptable for practical applications.

For example, if the variable of interest has not been measured at the required resolution or for the length of period required for predictions or for model calibration, the basin would be classified as ungauged basin with respect to this variable. Variable of interest can be for example: precipitation, runoff, erosion rates, sediment concentration in stream flow etc. So every basin is ungauged in some respect (Sivapalan et al., 2003).

The IAHS Decade on Predictions in Ungauged Basins (PUB) is an initiative of the International Association of Hydrological Sciences (IAHS). It is aimed at formulating and implementing appropriate science programmes to engage and energize the scientific community, in coordinated manner, toward achieving major advantages in the capacity to make reliable predictions in ungauged basins.

PUB defined, the prediction or forecasting of the hydrological response (e.g. Streamflows, groundwater, sediments etc.) of ungauged or poorly gauged basins, and its associated uncertainty using climatic inputs (observed, forecast or otherwise specified) soil, vegetation, geology, and topography including any predicted or expected future climate or land use changes, but without benefit of past observational time series of the particular hydrologic response that is being predicted i.e. with no possibility or allowance for direct calibration (Sivapalan et al., 2003). Prediction is concerned with estimating the frequency of occurrence, in the future, of events of any given magnitude, without reference to the times at which they could occur.

Approaches to Prediction in Ungauged Basins

A number of approaches are available for predictions of basin responses. Methods appropriate for ungauged basins include extrapolation of response information from gauged to ungauged basins, measurements by remote sensing. (e.g. passive and active radar, satellites etc.), application of process based hydrological models where the climate inputs are specified or measured and application of combined metrological and hydrological models without the need to specify precipitation inputs.

Hydrological Modeling for Ungauged Basins and its Importance

Hydrological modeling is a powerful technique of hydrologic system investigation for both the research hydrologists and practicing water resource engineer involved in the planning and development of integrated approach for management of water resources. Hydrological models are symbolic or mathematical representation of known or assumed functions

expressing various components of the hydrologic cycle. (Schultz, 1993). The main function of these models are hydrologic prediction and to understand various hydrologic processes. Hydrologic models for ungauged basins try to simulate the catchment behavior by solving the equations that govern the physical processes occurring within the catchment response for a given input.

One of the most frequently used event in the hydrology is the relation between the rainfall and the runoff. It determines the runoff signal which leaves the watershed from the rainfall signal received by the basin (Kumar and Bhattacharya, 2011). In it, a part of the hydrological cycle has been studied to express the runoff from the catchment as a function of rainfall and other catchment characteristics.

In 1932, Sherman introduced the concept of the unit hydrograph on the basis of principle of Superposition. During the last part of the 19^{th} century, and earlier part of 20^{th} century, most engineers used empirical formulae. Conceptual rainfall-runoff model attempt to represent hydrological process by mathematical equations and multiple layers of storage, e.g.: The Stanford Waterfall Model IV (Crawford and Linsley, 1996), HEC-1 U.S. Army Corps of Engineers, Tank model (WMO, 1975).

Thereafter, the concepts of physical hydrology was introduced and it led to an understanding of the physics of the hydrologic cycle. A fourth generation physical based model MIKE SHE (Refsgaard and Storm, 1995) is developed to apply for integrated water resource management.

Bhaskar et.al., (1997) derived the Geomorphological Instantaneous Unit Hydrograph (GIUH) from watershed geomorphological characteristics and then related to it the parameters of the Nash Instantaneous Unit Hydrograph (IUH) model for deriving its complete shape. Mishra et al., (2007) used SCS-CN method for computation of direct runoff from long duration rains for five Indian Watersheds. Jha and Smakhtin (2008) described different ranges of techniques, which are used for estimation of ungauged hydrological characteristics from climate and physiographic catchments parameters.

Hydrological Models of Ungauged Basins based on Remote Sensing, GIS and ANN

There has been growing need to study, understand and quantify the impact of major land use changes on hydrologic regime, both water quantity and quality. (Engman and Gurney, 1991).

Use of remote sensing in runoff estimation provides the input parameters for the models. Satellite data provides information such as land use/land cover, soil, vegetation, drainage etc. which, in combination with conventionally measured climatic and topographic parameters, constitute the required data for the various rainfall-runoff models. This information collected from satellite and other sources is stored as a geo-referred database in the Geographic Information System (GIS).

The GIS is used as a tool to store and retrieve the data for processing and computer based software module that can analyze and/or manipulate the retrieved data in order to generate the desired information in a specific form (Miloradov and Marjanovic, 1991). The conventional models used for prediction of stream discharge usually require considerable metrological and hydrological data. Remote sensing and GIS, in combination with appropriate rainfall runoff models, provide an ideal tool for the estimation of direct runoff, peak discharge and the hydrograph.

Many researchers (Das et.al., 1992; Tiwari et.al., 1991) used land use/land cover information derived from satellite data of LANDSAT, SPOT and IRS satellite and integrated with GIS to estimate SCS-CN and runoff.

Recently Artificial Neural Networks (ANN) has been considered as efficient alternative tool which can model the complex hydrologic systems and therefore widely used for prediction. (Sajikumar et.al., 1999). Sarkar et.al., (2006) developed back propagation ANN runoff model to simulate and forecast daily runoff for a part of the Sutlaj river basin in India. ANN models have been used to model complex non-linear input-output relationships in an extremely interdisciplinary field successfully. A linear multiple-input single-output (MISO) model coupled with the ANN is shown to provide a better representation of the rainfall-runoff relationship in large size catchments compared with linear and nonlinear MISO models. (Rajurkar et al., 2002). The natural behavior of hydrological processes is appropriate for the application of ANN method.

PROPOSED WORK

Hydrological modeling helps to understand the catchment features and its responses.

Following procedure shall be adopted for the proposed work

1. Digital elevation models, land cover map, flow direction and flow accumulation maps of study area are developed for hydrological analysis.
2. The rainfall-runoff model and ANN model shall be developed for estimation of the runoff from ungauged basin under study.
3. Comparison between these will be carried out and suitability of the model will be checked.

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